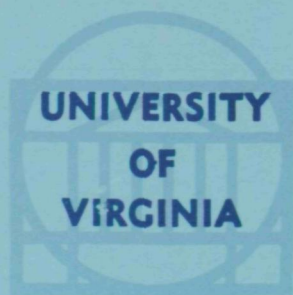


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PRELIMINARY RIDE-QUALITY EVALUATION
OF THE HM.2 HOVERFERRY

Memorandum Report 403216
Short-Haul Air Transportation Program

by
Eugene W. McClurken, Jr.
I. D. Jacobson
A. R. Kuhlthau

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SCHOOL OF ENGINEERING AND APPLIED SCIENCE
Department of Engineering Science and Systems

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Grant No. NGR 47-005-181

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INTRODUCTION

On May 31, 1974 two representatives of the University of Virginia made an evaluation of the ride on the HM.2 Hoverferry. This report presents the results of this single forty-minute exposure, departing from and returning to the Pilot Association Dock on the Elizabeth River in Norfolk, Virginia. Quantitative evaluations were made from aft seats on the starboard side for a sea state considered calm and visually estimated at one-half to one foot. The reader should note that any conclusions must be considered tentative at best, due to the limited amount of data. Also, in considering the results, the reader is cautioned that this type of craft is sensitive to sea state and thus the conclusions are based on ideal conditions.

Some drawings included in this report have been copied from literature distributed by the Hovermarine Corporation and should not be construed as precisely representing the configuration of the craft on which the reported measurements were made.

DESCRIPTION OF THE HM.2 HOVERFERRY

The HM.2 is an air cushion vehicle with rigid sidewalls and powered by marine-diesel-driven propellers and five lift fans. The craft is reportedly capable of speeds up to 35 knots with seating capacities of up to 60 passengers. Seats in the HM.2 craft were aircraft type and nonadjustable. Leg room, seat width, shape and firmness were judged satisfactory. Please refer to Figure 1 for approximate specifications and seating arrangement.

SUBJECTS

Two subjects, experienced in evaluating ride comfort, were located in seats designated "A" and "B" in the seating diagram of Figure 1. The subjects evaluated segments of the ride using multipoint comfort scales ranging from very comfortable to very uncomfortable. Approximately every two minutes the independent evaluations were recorded on tape with measured motion data.

DATA ACQUISITION SYSTEMS

The Portable Environmental Measuring System I (PEMS I) with stereo recorder was used to measure and record the following motion variables at location 'C' in the seating diagram:

- Linear accelerations
 - Vertical
 - Transverse (side-to-side)
 - Longitudinal (forward-aft)
- Angular rotation rates
 - Pitch (bow up and down)
 - Yaw (bow left and right)
 - Roll

Sound-level measurements were made with both A and C weightings. A-weighted measurements were made coincident to subjective responses and recorded manually. C-weighted measurements were recorded on tape in both oral and analog fashion.

RESULTS

Standard analyses developed at the University of Virginia were applied to the data, calculating motion variables and their effect on comfort and passenger satisfaction (1). Plots of each variable versus subjective response were then analyzed, yielding the following observations.

1. Within the limited ranges of variables experienced, comfort ratings were apparently affected more strongly by length of exposure to the ride environment than by the rms value of any single motion variable or combination of motion variables (Figure 2).
2. For the first twenty minutes, and for a calm sea state, subjective responses were not uncomfortable; however, beyond twenty minutes exposure time, there was noticeable comfort degradation despite the fact that the sea state remained the same.
3. A mild predominance of certain frequencies occurred in the power spectra of the motion variables:

Yaw	.35, .7, 1.15 Hz \pm .1
Roll	.35, .85, 1.15 Hz \pm .1
Pitch	.35 Hz \pm .1
Longitudinal	.3, .8, 1.1 Hz \pm .1
Transverse	.4, 1.15 Hz \pm .1
Vertical	.25, .7, 1.05 Hz \pm .1

It should be noted that these frequencies fall in the range known to affect human motion sickness.

Refer to Figures 3 and 4 for typical power spectra in the frequency range 0 - 1.25 Hz. There was no appreciable energy content above 3 Hz.

4. No significant consistent cross correlations of motion variables were apparent.
5. Noise levels encountered in the passenger compartment, 84 - 86 dB(A) and 104 - 106 dB(C), were comparable or slightly lower than cruise conditions of commuter aircraft.

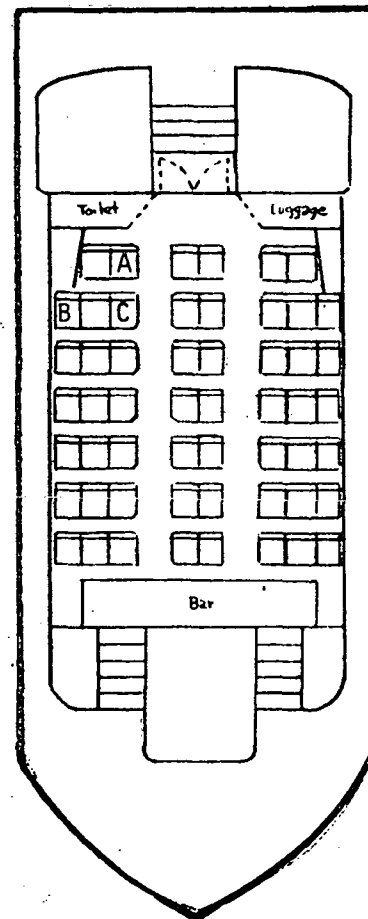
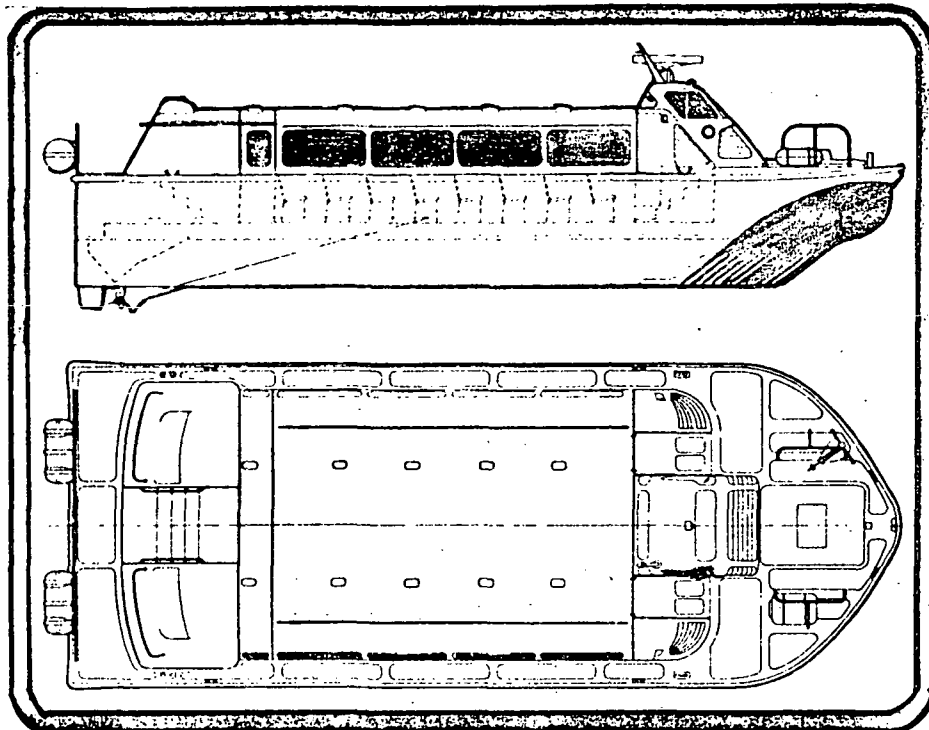
CONCLUSIONS

1. Under the specific conditions encountered in this single test opportunity, exposures in excess of twenty-five minutes are not recommended. This criterion would suggest satisfactory service between points up to 14 nautical miles apart. Rough sea states may significantly reduce the recommended exposure time.
2. Based on previous work in aircraft, a neutral response would indicate that approximately 80% of the passengers are satisfied. A response of $C = 5$ (the worst encountered) indicates only 68% would be satisfied. In fact, for comparison, if the motions experienced in the Hoverferry had been encountered in a small commercial airliner (e.g., Twin Otter), they would have elicited responses in the comfortable region as shown in

Figure 2. This would correspond to 95% of the passengers being satisfied. The difference is most likely due to the presence of significant low frequency motions in the Hover-ferry ride.

REFERENCES

1. Kuhlthau, A. R. and I. D. Jacobson, "Analysis of Passenger Acceptance of Commercial Flights Having Characteristics Similar to STOL," Canadian Aeronautics and Space Journal, Vol. 19, No. 8, pp. 405-409, October 1973.



Leading Particulars

Dimensions

Overall length	51' (15.54 m)
Overall beam	20' (6.09 m)
Overall height	13'9" (4.19 m)
Height above waterline - on cushion	11'10 1/2" (3.62 m)
Height above waterline - off cushion	8'10 1/2" (2.71 m)
Draught on cushion	2' 10 1/2" (0.87 m)
Draught off cushion	4'10 1/2" (1.49 m)
Cabin size (length x width)	22' x 16' (6.70 m x 4.88 m)
Cabin height at center line	6'6" (1.98 m)
Entrance size (height x width)	6' 3" x 4' (1.90 m x 1.22 m)

*These heights and draughts take account of 2° bow up trim on cushion.

Power Plants and Systems

Propulsion engines	Two 320 B.H.P. Cummins VT8-370M turbocharged marine diesels
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Lift fan engine

Propellers	2 3 blade - pitch 21" (53.3 cm) diam. 15" (38.1 cm)
Fans	5 x direct driven centrifugal type
Fuel capacity	(175 U.S. galls) 662 litres

Pay-loads

Normal pay-load	60 passengers
Freight	11,000 lb (4,990 kg)

Weights

Standard gross weight	43,500 lb (19,732 kg)
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Performance at standard gross weight

Maximum speed - calm water, no wind	35 kt (65 kph)
Acceleration - 0 - 35 kt	36.5 secs
Deceleration - from maximum speed (normal)	270' (76 m)
(emergency)	150' (45 m)
Endurance	4.8 hrs.



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FIGURE 1. THE CRAFT: HM.2 HOVERFERRY

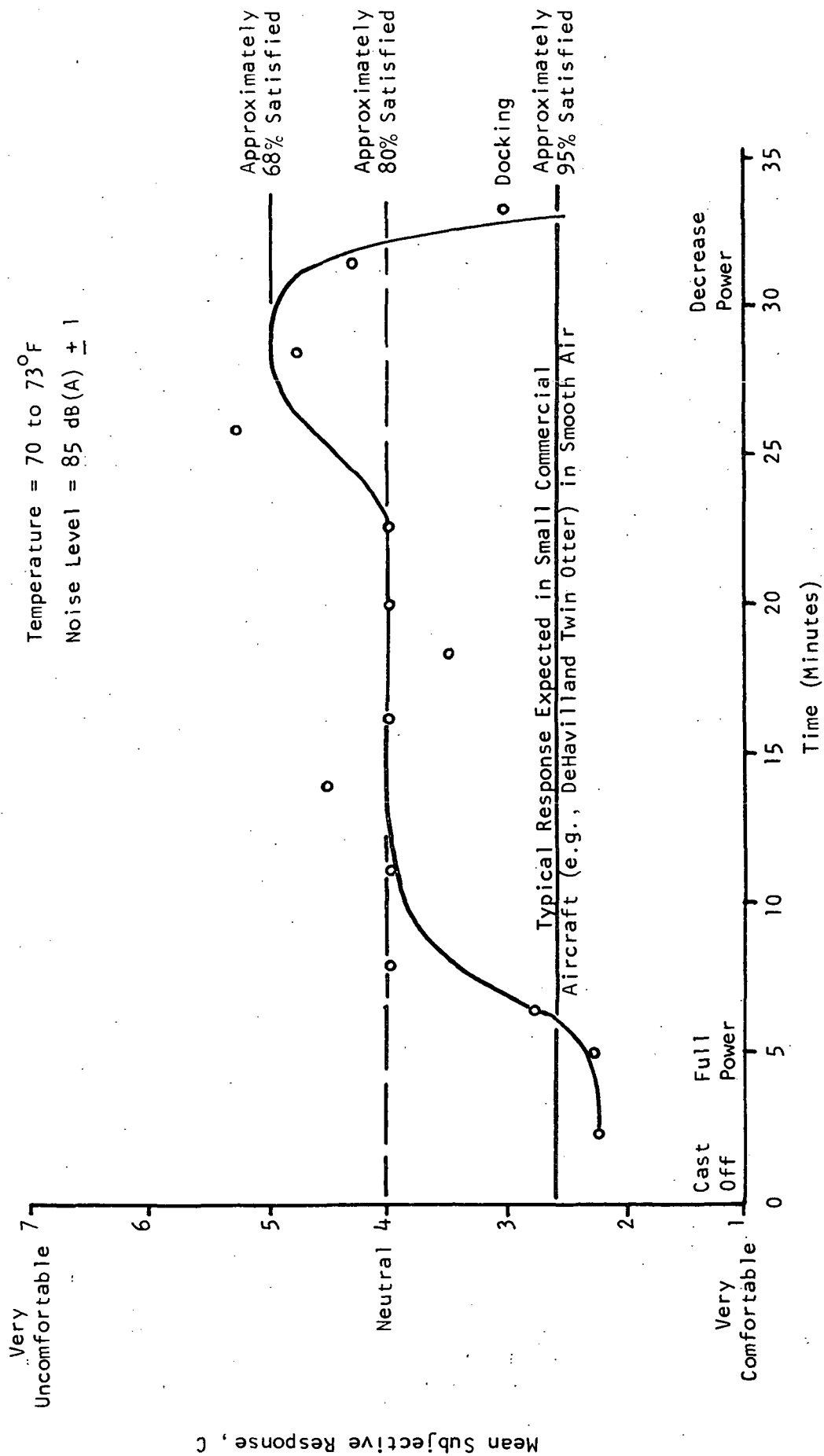


FIGURE 2. SUBJECTIVE RESPONSE VS. EXPOSURE TIME

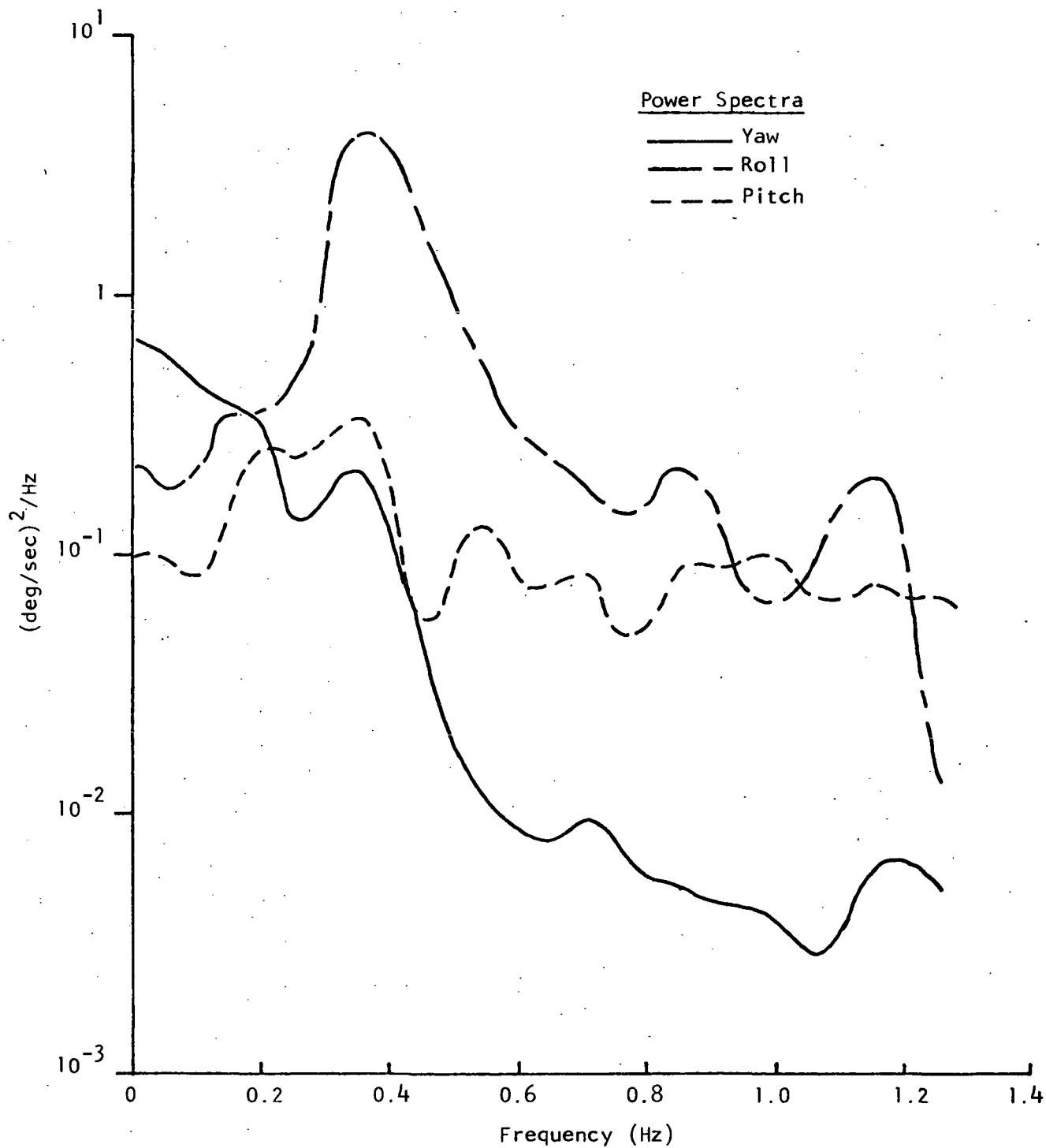


FIGURE 3. ROTATION RATE POWER SPECTRA

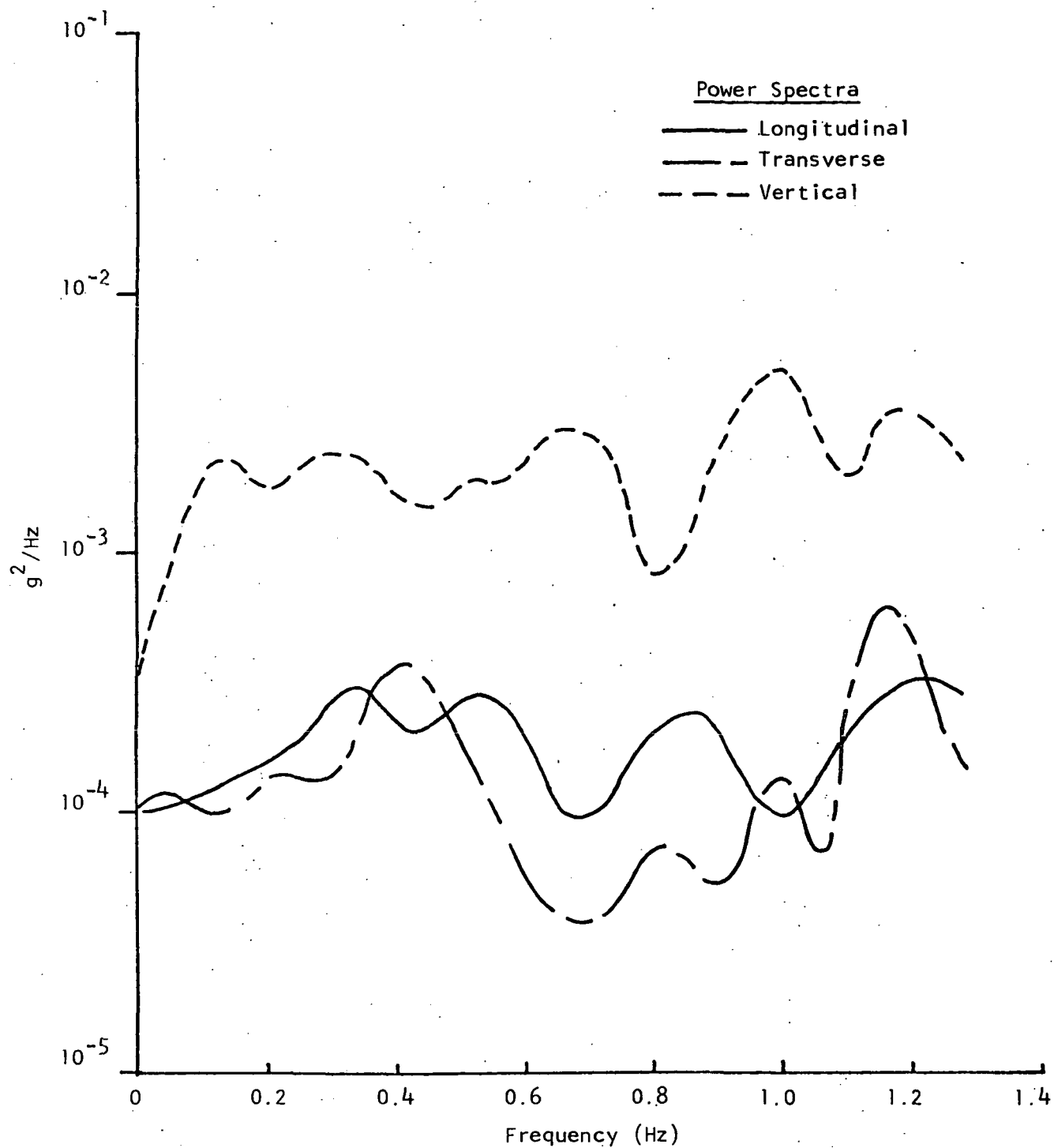


FIGURE 4. LINEAR ACCELERATIONS POWER SPECTRA